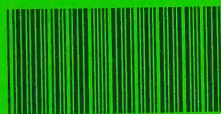


OPERATING AND MAINTENANCE
INSTRUCTIONS FOR
MODEL 208R
MICROMULTIMETER



MP MASTER



MA30146

5725 KEARNY VILLA ROAD, BOX 623, SAN DIEGO 12, CALIFORNIA



OPERATING AND MAINTENANCE

INSTRUCTIONS FOR
MODEL 208P
MICROMULTIMETER

ACCESSORIES	
MODEL NO.	NAME
208R-01	Current Probe
208R-02	Volt/Chms Probe
208R-03	Output Probe

COHU ELECTRONICS, INC.
KIN TEL Division
5725 Kearny Villa Road
Box 623
San Diego
California 92112

This material is the property of Cohu Electronics, Inc. It is furnished for repair and maintenance of KIN TEL products only, and its reproduction or use in any other way or for any commercial purpose without prior permission is forbidden. All rights in this material is reserved.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
LIST OF ILLUSTRATIONS	iv
LIST OF TABLES	v
TABLE 1. Specifications, Model 208R Micromultimeter	vi
I GENERAL DESCRIPTION	1-1
1-1. General	1-1
1-2. Description	1-1
1-3. Specifications	1-2
1-4. Controls	1-2
1-5. Probe Storage and Connections	1-2
1-6. Accessories	1-4
1-7. Applications	1-4
1-8. Warranty	1-5
II OPERATING INSTRUCTIONS	2-1
2-1. General	2-1
2-2. Initial Check	2-1
2-3. Installation	2-1
2-4. Power Line Voltages	2-1
2-5. Power Cord	2-1
2-6. 115-volt Operation	2-2
2-7. 230-volt Operation	2-2
2-8. Cooling	2-2
2-9. Operating Controls	2-2
2-10. Operating Procedures	2-3
2-11. Special Operating Procedures for Low Level Measurement.	2-3
2-12. Minimization of Thermocouple Effects	2-3
2-13. Minimization of Spurious Signals	2-4
2-14. DC Amplifier Operation	2-5

2-15.	DC Voltmeter Operation	2-7
2-16.	DC Ammeter Operation	2-8
2-17.	Extended Range Ammeter Operation	2-9
2-18.	Galvanometer Operation	2-10
2-19.	Ohmmeter Operation	2-10
2-20.	LO OHMS Measurement	2-10
2-21.	HI OHMS Measurement	2-11
2-22.	Ohms Measurement With Increased Resolution and Accuracy	2-11

LIST OF ILLUSTRATIONS

FIGURE NUMBER	TITLE	PAGE
1-1.	KIN TEL Model 208R Micromultimeter.	1-1A
2-1.	Transformer Jumper Connections for 115-volt and 230-volt Operation	2-2A
2-2.	Location of Model 208R Operating Controls	2-2B
2-3.	Simplified AMPL.-METER Switching	2-6A
2-4.	Simplified Diagram of Four-terminal Method of Resis- tance Measurement	2-11A

LIST OF TABLES

TABLE NUMBER	TITLE	PAGE
2-1	Measurement Capabilities and Quantitative Prefixes . .	2-2B
2-2	SI01, Range Switch	2-3A
2-3	SI02, Function Switch	2-3B
2-4	SI03, Power/Filter Switch	2-3B
2-5	Miscellaneous Controls: SI04, HI OHMS Range Switch; SI05, OHMS READ Switch; SI06, Interlock; SI07, AMPL./ NETER Switch; and RI36, ZERO Control	2-3C
2-6	Voltage Amplification	2-6B
2-7	Extended Current Ranges: Current Measurement With Reduced Shunt Resistance	2-10A
2-8	Resistance Measurement With Increased Resolution and Accuracy	2-12A

Table 1. Specifications, Model 208R Micromultimeter

MEASUREMENT RANGES:

VOLTAGE (19 RANGES)

microvolt to 1 kilovolt, end scale, in x1 and x3 overlapping ranges.

CURRENT (19 RANGES)

100 picoamperes to 100 milliamperes, end scale, in x1 and x3 overlapping ranges.

RESISTANCE (19 RANGES)

microhm to 300 ohms, end scale, in x1 and x3 overlapping ranges.

kilohm to 1 gigohm (1×10^9 ohms), end scale, in decade ranges.

ACCURACY: (Maximum Magnitude of Instrument Error)

VOLTAGE: 1% of end scale or 100 nanovolts, whichever is greater.

CURRENT: 1% of end scale or 10 picoamperes, whichever is greater.

RESISTANCE: 2% of end scale or 100 microhms, whichever is greater, on ranges from 1 milliohm through 100 megohm ranges.

1% of end scale on 1 gigohm range.

TEMPERATURE RESISTANCE:

VOLTAGE RANGES: Greater than:

1 megohms on 1 microvolt range

1 megohms on 3 microvolt range

10 megohms on 10 microvolt through 1 volt ranges. (Approximately 30

ohms on 1 volt range)

10 megohms $\pm 3\%$ on 3 volt through 1 kilovolt ranges

CURRENT RANGES:

10 kilohms on 100 picoampere through 100 microampere ranges.

10 ohms on 300 microampere through 100 milliamperer ranges.

RESISTANCE THROUGH OR VOLTAGE APPLIED TO UNKNOWN RESISTANCE:

LOW OHMS RANGES:

1 milliamperer on 1 milliohm through 300 ohm ranges

HIGH OHMS RANGES:

Less than or equal to 1 volt on 1 kilohm through 1 gigohm ranges.

FILTER:

FREQUENCY (CPS)	ATTENUATION
15	3 db
60	40 db
120	40 db
400	36 db
600	40 db

MAXIMUM INPUT OVERLOAD: (Duration of Overload NOT to Exceed 10 Seconds)

VOLTAGE OPERATING MODE:

30 volts maximum, 1 microvolt through 1 volt ranges.

100 volts maximum, 3 volt through 1 kilovolt ranges.

CURRENT OPERATING MODE:

100 milliamperes maximum, 100 picoampere through 100 microampere ranges.

100 milliamperes maximum, 300 microampere through 100 milliamperer ranges.

Overloads will produce drift and offset effects on the more sensitive ranges. Allow sufficient time for instrument to stabilize for normal operation after severe overloads.

RECOVERY TIME: (To $\frac{1}{2}$ 5% of Final Value) within

Less than 2 seconds plus range response time after an overload of 1000% of scale.

Duration of overload not to exceed 10 seconds.

DRIFT: (Random Meter Deflection)

Approximately 2% on the 2 most sensitive voltage, current, and resistance

Less than 1% on all other ranges.

SETUP TIME:

minutes

DRIFT:

Less than 2×10^{-11} amperes, 2×10^{-7} volts, and 2×10^{-4} ohms full scale on most sensitive voltage, current, and resistance ranges (after 30-minute warm-up). Voltage source resistance less than 10 kilohms.

METER:

A. D'Arsonval type, zero-center galvanometer with taut band suspension and mirror scale.

B. Two linear zero center scales calibrated 3-0-3 and 10-0-10.

POLARITY:

Indicates + or - on galvanometer scale.

ELECTRONIC ZERO ADJUSTMENT:

Greater than ± 10 microvolts equivalent input

GALVANOMETER:

A. VOLTAGE GALVANOMETER: (Most sensitive range)

CURRENT SENSITIVITY: $\pm 2 \times 10^{-18}$ amperes (2 femtoamperes) per linear scale divisionVOLTAGE SENSITIVITY: $\pm 2 \times 10^{-8}$ volts (20 nanovolts) per linear scale divisionPOWER SENSITIVITY: 4×10^{-23} watts per scale division at null 10^{-19} watts full scaleINPUT RESISTANCE: 1×10^7 ohms (10 megohms)

RESPONSE TIME: <10 seconds to within 95% of final value, typically 5 seconds

B. CURRENT GALVANOMETER: (Most sensitive range)

CURRENT SENSITIVITY: $\pm 2 \times 10^{-12}$ amperes (2 picoamperes) per linear scale divisionVOLTAGE SENSITIVITY: $\pm 2 \times 10^{-8}$ volts (20 nanovolts) per linear scale divisionPOWER SENSITIVITY: 4×10^{-20} watts per scale division at null 10^{-16} watts full scaleINPUT RESISTANCE: 1×10^6 ohms (10 kilohms)

RESPONSE TIME: <10 seconds to within 95% of final value, typically 5 seconds

C. SOURCE RESISTANCE: Voltage — 0 to 10 kilohms
Current — Not restricted

AMPLIFIER OUTPUT:

A. OUTPUT IMPEDANCE: Less than 1 ohm at DC.

B. OUTPUT VOLTAGE: 1 volt at end scale (all ranges) with metered output. (Less than 3 volts end scale for overload conditions.)

10 volts at end scale as amplifier only. (Less than 30 volts for overload conditions.)

C. OUTPUT CURRENT: 10 milliamperes maximum

D. OUTPUT LOADS:

METER MODE: 1. Resistive: Greater than or equal to 100 ohms;
2. Capacitive: Less than or equal to 1 microfaradAMPLIFIER MODE: 1. Resistive: Greater than or equal to 1 kilohm;
2. Capacitive: Less than or equal to 1 microfarad

When floating instrument, output probe connector shell and terminal is at same DC potential as low side of input probe.

Table 1. Specifications, Model 208R Micromultimeter (Continued).

COMMON MODE PARAMETERS (GUARDED CIRCUIT):

COMMON MODE VOLTAGE COEFFICIENT (CONVERSION): (Chassis — Guard Shield)

DC: Less than 10^{-6} (10 kilohm unbalanced input source)AC: Less than 10^{-7} at 60 cps (10 kilohm unbalanced input source)

COMMON MODE SHORT CIRCUIT CURRENT:

CHASSIS TO GUARD SHIELD (C-D):

DC: Less than 100 picoamperes (10^{-10} amperes)AC: Less than 5 nanoamperes (5×10^{-9} amperes), RMS, at 60 cps

COMMON TO GUARD SHIELD (B-C):

DC: Less than 5 nanoamperes (5×10^{-9} amperes)AC: Less than 5 nanoamperes (5×10^{-9} amperes), RMS, at 60 cps

COMMON MODE IMPEDANCE: (Chassis — Guard Shield)

Greater than or equal to 1 gigohm (10^9 ohms) paralleled by less than 5 picofarads (common mode input capacity).

MAXIMUM ALLOWABLE COMMON MODE VOLTAGE:

DC: Up to 1000 volts.

AC: Up to 1000 volts peak

OPERATING CONDITIONS:

POSITION:

Amplifier Operational Mode: All Positions
Meter Operational Mode: Rackmounted

TEMPERATURE:

AMBIENT) $+20^{\circ}\text{C}$ to $+30^{\circ}\text{C}$ (factory calibrated), or any $\pm 5^{\circ}\text{C}$ span within the range $+15^{\circ}\text{C}$ to $+40^{\circ}\text{C}$. Calibrate with ambient temperature at mean value of desired span.

TEMPERATURE:

WITH BATTERY PACK: -50°C to $+70^{\circ}\text{C}$ WITH BATTERY PACK: -10°C to $+50^{\circ}\text{C}$

POWER LINE EFFECTS:

A. SUSTAINED LINE

VOLTAGE CHANGE: For 10% change, zero shift is less than $\pm 10\%$ of most sensitive voltage, current, or resistance range (≤ 100 nanovolts input voltage).

B. LINE TRANSIENTS:

 $\pm 10\%$ line transients produce meter deflections small in comparison with BOUNCE specification.

POWER INPUT:

115 volts, AC, ± 10 volts; or 230 volts, AC, ± 20 volts, 50 to 400 cps, or internal battery; at approximately 12 VA.

BATTERY OPERATION:

Provision for 6 hours' operation from accessory rechargeable, internal battery pack.

Battery charging and trickle charging provisions are standard in basic instrument.

INTERNAL PROBE STORAGE:

Self-contained storage for 7 probe carriers: 2 active probes, 1 active output cable, and 4 inactive probes.

PANEL FINISH:

KIN TEL semi-gloss, light gray enamel (F.S.N. 26251) with black trim and silk-screened lettering. The case is finished in matching gray wrinkled enamel. (Other finishes can be furnished on special order. Contact factory for details and price.)

DIMENSIONS:

19" wide, 17" deep, 7" high, rack mounted.

WEIGHT:

A. NET WEIGHT: 48 pounds, 12 ounces.

B. SHIPPING WEIGHT: 62 pounds.

PRICE: MODEL 208R BASIC SYSTEM WITHOUT ACCESSORIES

\$1495.00 (additional export charge)

MODEL 208R-01 CURRENT PROBE: (Mounted on Probe Slide)

A. LENGTH: 4'6"

B. TERMINATIONS: Insulated alligator clips

MODEL 208R-02 VOLT-OHMS PROBE: (Mounted on Probe Slide)

A. LENGTH: 4'6"

B. TERMINATIONS: insulated, (2) two-conductor clips

MODEL 208R-03 OUTPUT PROBE: (Mounted on Probe Slide)

A. LENGTH: 4'6"

B. TERMINATIONS: Two insulated, five-way binding posts on $\frac{1}{4}$ " centers and one metal five-way binding post connected to "C" shield.

MODEL 208R-20 BATTERY PACK:

A. TYPE: Sealed, rechargeable, long-life, nickel-cadmium battery.

B. VOLTAGE: +30 volts and -30 volts at 120 mA.

C. MOUNTING: Integral mounting in 208R.

NOTE: Spare circuit boards (assembled) and extension boards (to facilitate maintenance) are available in kit form as spare parts.

KIN TEL reserves the right to change specifications and prices without notice.

SECTION I
GENERAL DESCRIPTION

1-1. GENERAL. This manual contains operation and maintenance instructions for the KIN TEL Model 208R Micromultimeter (Figure 1-1) and accessories. This manual is divided into six sections. Sections I through IV apply specifically to the basic instrument and to its use with operational accessories. Section V applies specifically to accessories of the basic instrument and contains additional operating instructions on the use of special purpose accessories. Section VI contains the latest change information affecting this manual.

Figure 1-1. KIN TEL Model 208R Micromultimeter. (Left front perspective view of panel, photograph KT 5214)

1-2. DESCRIPTION.

The Model 208R is a precision DC amplifier having very precise net gains from 10^{-3} to 10^6 . Gains are selected by setting a front panel control to the desired range and a function control to the type of electrical quantity being measured. The instrument's precision voltage dividers, shunts, and currents enable the amplifier to function as a precision instrument for measuring voltage, current, and resistance. The meter is a taut-band, D'Arsonval galvanometer movement with two zero-center scales, 3-0-3 and 10-0-10, and a mirror-backed scale to enable elimination of parallax when reading the pointer position. The amplifier output is directly proportional to its input. End scale output is ± 1 volt when used as a meter and is linear to ± 10 volts (or, with the pointer offset to end scale position, to ± 20 or -20 volts) when used as an amplifier. The low impedance output is ideal for driving strip chart recorders.

The micromultimeter is housed in a shielded enclosure which contains all metering circuits, provides for optional accessories, and provides storage for 7 probes. This instrument has solid-state circuitry throughout. Most circuitry is mounted on plug-in cards (etched circuit boards) which plug into a main interconnecting board. The plug-in cards and card extenders greatly facilitate maintenance. A particularly important structural feature is the double shielded box-within-a-box method of construction which places all active components and associated circuitry in separate, shielded enclosures within the main shielding enclosure. This double shield makes the instrument virtually insensitive to voltages between the measurement circuit, the case, and power system ground. The second shield permits shielding of the measurement circuit to create an effective impedance to ground much greater than the direct capacity of an instrument of this type.

1-3. OPERATING PRINCIPLE.

Detailed specifications for the Model 208R micromultimeter and its accessories are provided in Table 1 which immediately precedes this section.

1-4. FRONT PANEL.

All controls appear on the front panel except S107, the METER/AMPLIFIER switch, which is located immediately behind the probe storage box door.

1-5. PROBE STORAGE AND CARRYING CASE.

Storage for seven probes, each mounted on individual slides, is provided within the micromultimeter enclosure by a separate, shielded box. All probes in this box are accessible from the front panel through a hinged door. The probe box is divided into two compartments. The upper compartment provides storage for four inactive probes. The lower compartment accommodates three active probes, the METER/AMPLIFIER switch, S107, and an interlock switch, S106. Three connectors (J101, J102, and J103) at the rear of the bottom shelf mate with their respective probes when the probe slide is fully inserted. Cutouts in the panel below each active probe permit the probe cable to extend through the panel when the compartment door is closed. This feature preserves the integrity of the shielding system.

The output probe connector, J103, is active for all positions of the range switch, S101, of the function switch, S102, and of the power switch, S103, except OFF and CHG.

The volt/ohms probe connector, J101, is active for all positions of the function selector switch, S102, except the CURRENT position and of the power switch, S103, except OFF and CHG.

The current probe connector, J102, is active only when the function selector switch is set to CURRENT, and for all positions of the power switch, S103, except OFF and CHG.

An additional connector, J104, located in the meter and switch compartment connects with the optional Model 202P-100 Battery Pack power plug, P104.

1-6. ACCESSORIES.

Accessories are fully described in Section V of this manual. The following accessories are available: Model 208R-01 Current Probe, Model 208R-02 Volt/Ohms Probe, Model 208R-03 Output Probe, and Model 208R-20 Battery Pack.

1-7. APPLICATIONS.

This instrument has applications wherever a multimeter or VTVM would be used including applications where those instruments lack the required accuracy. Moreover, the Model 208R Micromultimeter's ranges extend far below and above the limits of common test instruments and of specialized, restricted range precision test instruments. This instrument is ideally suited for use by scientists and engineers working with low level phenomena requiring the measurement of very low voltages, very low currents, and both very low and very high resistances. Direct measurements of current is limited to the low current region but may be extended to the high current region by procedures detailed in Section II. Voltage measurements span the entire range of voltages normally encountered. The resistance ranges extend from the lowest resistances of practical significance to the highest resistances likely to be encountered. The amplifier output capabilities permit the use of this instrument with external recording devices simultaneously with its measurement capabilities or as a precision DC amplifier only. Since the micromultimeter is a very sensitive galvanometer also, its usefulness is extended to a wide variety of applications in physical, medical engineering, research and development. The portability of this instrument

and provision for battery operation make this the ideal multimeter for mobile military laboratories and repair stations. Moreover, the absence of mercury bias cells makes this instrument suitable for use in submarines and aircraft or in other closed environments such as missile silos.

1-8. WARRANTY.

The standard KODAK ELECTRONICS INC., KIN TEL Division warranty certificate (Form No. 3-212) is an integral part of this manual and applies to this instrument and its accessories. No statement in this manual is to be construed as modifying the enclosed warranty in any way.

Section II

OPERATING INSTRUCTIONS

2-1. GENERAL. Operating instructions for the Model 208R Micromultimeter include receiving inspection, installation, the functions of its operating controls and connectors, and operation of the instrument as an amplifier, a voltmeter, an ammeter, an ohmmeter, and as a galvanometer. These instructions also include the use of the Model 208R-01 Current Probe, Model 208R-02 Volt-Ohms Probe, and Model 208R-03 Output Probe. The operation of other accessories is treated in Section V.

2-2. INITIAL CHECKS.

Instrument operation should be checked as soon as possible after receipt of the instrument to detect any concealed damage that may have been caused during shipment. (See form P-293-5-62-5M which is enclosed with the instrument). Check the instrument in accordance with the information and instructions in this section.

2-3. INSTALLATION.

The Model 208R Micromultimeter may be installed in a standard 19-inch electronic equipment rack or is light enough to be used as a portable bench instrument. Installation instructions cover power line voltages and cooling provisions.

2-4. POWER LINE VOLTAGES.

The Model 208R is designed to operate on 115-volt or 230-volt, 50 to 400 cps, single phase, AC power or from an accessory internal battery. The operating line voltage tolerance is ± 10 volts for 115-volt operation and ± 20 volts for 230-volt operation. This instrument is normally shipped from the factory wired for 115-volt operation.

2-5. POWER CORD.

This instrument is equipped with a 3-wire power cord (two AC conductors and one ground conductor) 7.5 feet long which is fitted with a polarized, U-grounding male connector approved by the National Electrical Manufacturers' Association. An adapter having a ground connection is required to use this instrument with a standard, two-contact receptacle, and the ground lead of the adapter should be grounded to the outlet box for protection of personnel using this instrument.

Operation of this instrument on power from 230-volt or from 100 cps mains will require the use of an adapter plug or cable which has a suitable mating connector for the power receptacle. Instructions for battery operation are provided in Section V.

2-1. **115-VOLT OPERATION.** Verify that the instrument is wired for 115-volt operation. This may be done by checking for approximately 100 ohms resistance between the blades of the power connector. A resistance of approximately 350 ohms indicates that the unit is wired for 230 volts, and that the transformer jumper connections must be changed. Figure 2-1, View A, illustrates the power transformer jumper connections for 115-volt operation. Ensure that a type 3AG, 0.2A, 125V, Slo-Blo fuse is installed in fuse holder.

Figure 2-1. Transformer Jumper Connections for 115-Volt and 230-Volt Operation.

2-7. **230-VOLT OPERATION.** Verify that the instrument is wired for 230-volt operation. This may be done by checking for approximately 350 ohms resistance between the blades of the power connector. A resistance of approximately 100 ohms indicates that the unit is wired for 115 volts and that the transformer jumper connections must be changed. Figure 2-1, View B, illustrates the power transformer jumper connections for 230-volt operation. Ensure that a type 3AG, 0.1A, 250V, Slo-Blo fuse is installed in fuse holder.

2-8. **COOLING.** The 208R does not require forced-air ventilation but ventilation louvers should have at least 3 inches clearance to permit free circulation of air through them.

2-9. OPERATING CONTROLS.

The operating controls of this instrument are illustrated in Figure 2-2. The functions of these controls are described in Tables 2-2 through 2-5. Table 2-1 is a convenient reference which relates all ranges to the standard quantitative prefixes and the corresponding powers of 10.

Figure 2-2. Location of Model 208R Micromultimeter Operating Controls
(KT Photo 5215)

2-10. **Measurement Capacitors and Quantitative Prefixes**

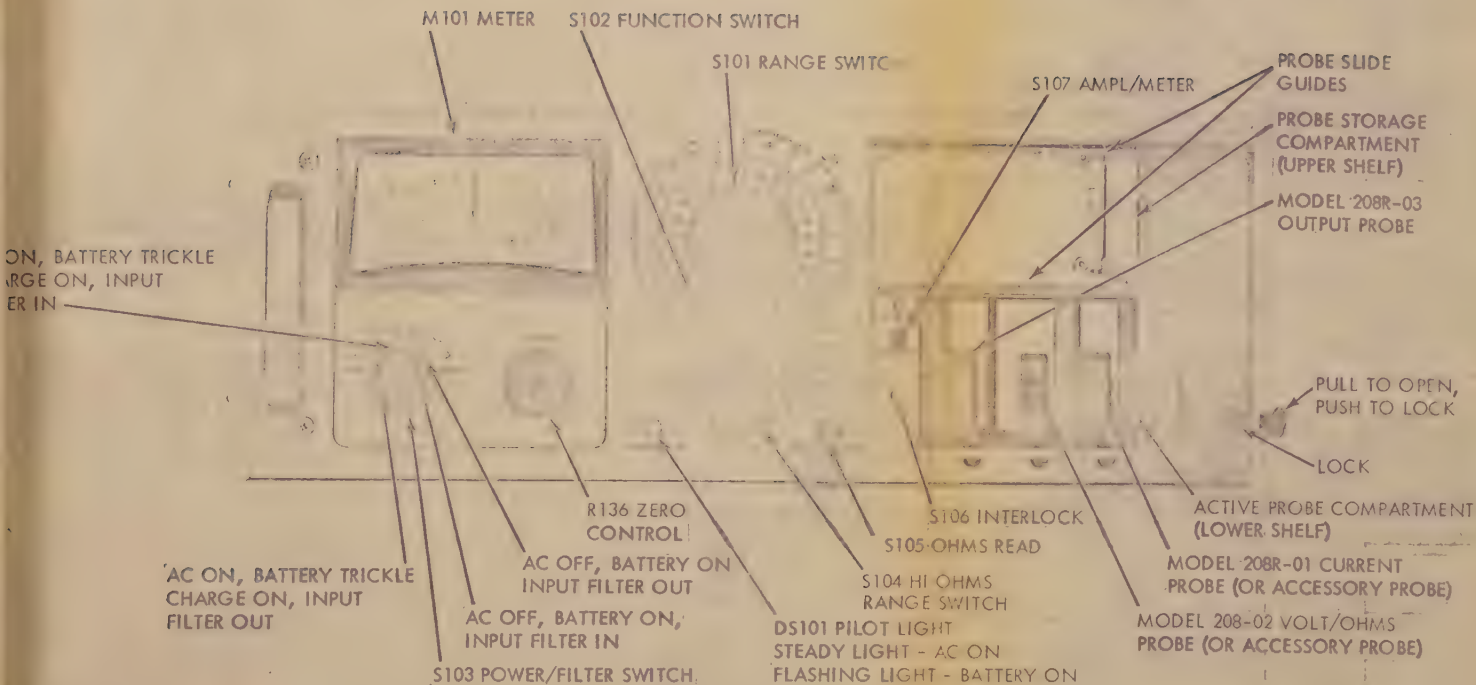


Table 2-1. Measurement Capabilities and Quantitative Prefixes.

10^n	PREFIX/ SYMBOL	RANGE (END SCALE)		
		CURRENT	VOLTAGE	RESISTANCE
10^{-15}	femto- (f-)			
10^{-12}	pico- (p-)	2 pA (1st minor division) 100--300 pA (0.1--0.3 nA)		
10^{-9}	nano- (n-)	1--300 nA	20 nV (1st minor division)	
10^{-6}	micro- (μ -)	1--300 μ A	1--300 μ V	20 p Ω (1st minor division)
10^{-3}	milli- (m-)	1--100 mA	1--300 mV	1--300 m Ω
10^0			1--300 V	1--300 Ω
10^3	kilo- (K-)		1 KV	1--100 K Ω
10^6	mega- (M-)			1--100 M Ω
10^9	giga- (G-)			1 G Ω (1 K M Ω)

Figure 2-1. S101, Range Switch

Figure 2-3. S102, Function Switch

Figure 2-4. S103, Power/Filter Switch

Figure 2-5. Miscellaneous Controls: S104, HI OHMS Range Switch; S105, OHMS LEAD; S106, Interlock; S107, AMPL/METER Switch; and R136, ZERO Control

2-1. OPERATING PROCEDURES.

The Model 208R Micromultimeter is a precision, multi-purpose, laboratory grade instrument which provides the following functions: amplification, generation of a precise analog voltage representing the voltage, current, or resistance connected to its input terminals; measurement of current, voltage, and resistance; and null indication for voltages and currents.

The following operating procedures describe the operation of the 208R as an amplifier, a voltmeter, an ammeter, an ohmmeter, and an electronic galvanometer in conjunction with the basic probes: Model 208R-01 Current Probe, Model 208R-02 Volt/ohms probe, and Model 208R-03 Output Probe. Operation with other probes is described in the paragraphs treating the specific probe concerned.

2-1.1. SPECIAL OPERATING PROCEDURES FOR LOW LEVEL MEASUREMENTS.

The sensitivity of the micromultimeter, especially when it is being used to make low level measurements, far exceeds the sensitivity of most instruments in common use. Thermocouple noise effects which are obscured by less sensitive instruments are clearly visible. Therefore operators of this instrument should make the following techniques a vital part of their measurement procedures. Two principal techniques for minimizing low level effects are: insulation of measurement points and electrostatic shielding of measurement points.

2-1.2. MINIMIZATION OF THERMOCOUPLE EFFECTS. The following procedures will minimize the effect of thermocouples present at points of probe contact with circuit components.

Table 2-2. S101, Range Switch.

SWITCH POSITION*	FUNCTION SWITCH SETTING				FEEDBACK db	INPUT ATTENUATION db
	CURRENT	VOLTS	10 OHMS	10 OHMS		
1	.1 nA	1 μ V	1 m Ω		40	0
2	.3 nA	3 μ V	3 m Ω		40	0
3	1 nA	10 μ V	10 m Ω		60	0
4	3 nA	30 μ V	30 m Ω		60	0
5	10 nA	100 μ V	100 m Ω		60	0
6	30 nA	300 μ V	300 m Ω		60	0
7	100 nA	1 mV	1 Ω		60	0
8	300 nA	3 mV	3 Ω		60	0
9	1 μ A	10 mV	10 Ω		60	0
10	3 μ A	30 mV	30 Ω		60	0
11	10 μ A	100 mV	100 Ω		60	0
12	30 μ A	300 mV	300 Ω		60	0
13	100 μ A	1 V		1 K Ω 10 1 K Ω	100	0
14	300 μ A	3 V			70.458	** 20 (CURRENT) 80 (VOLTS)
15	1 mA	10 V			60	20 (CURRENT) 80 (VOLTS)
16	3 mA	30 V			70.458	20 (CURRENT) 80 (VOLTS)
17	10 mA	100 V			60	20 (CURRENT) 80 (VOLTS)
18	30 mA	300 V			70.458	20 (CURRENT) 80 (VOLTS)
19	100 mA	1 KV			80	20 (CURRENT) 80 (VOLTS)

*Numbered from maximum counter-clockwise position.

**Attenuation when FUNCTION switch is set to function indicated.

Table 2-3. S102, Function Switch.

POSITION	FUNCTION	INTERNAL ACTIONS
1	HI OHMS	A. Connects Volt-Ohms probe and disconnects current generator output leads and Current probe. B. Converts amplifier to an operational amplifier with current generator connected between input and output. C. Opens COMMON connection to input filter.
2	LO OHMS	A. Connects Volt/Ohms probe and connects current generator to current generator output leads. B. Closes COMMON connection to input filter.
3	VOLTS	A. Connects Volt/Ohms probe and disconnects current generator output leads. B. Switches current generator off. C. Closes COMMON connection to input filter.
4.	CURRENT	A. Connects Current probe and disconnects Volt/Ohms probe. B. Connects input to ^{correct} current shunt.

Table 2-4. S103, Power ^{Filter} Switch.

POSITION	FUNCTION
1	Power off.
2	AC power on. Input Filter out.
3	AC power on. Input Filter in.
4	Battery power on. Input Filter in.
5	Battery power on. Input Filter out.
6	AC power on. Battery charger on. DC power to instrument off. and output shorted to COMMON

Table 2--. Miscellaneous Controls: S104, HI OHMS Range Switch; S105, OHMS READ; S106, Interlock; S107, AMPL/METER Switch; and R136, ZERO control.

	NAME	FUNCTION
	HI OHMS	Selects HI OHMS measurement range in decade steps from 1K ohms to 1K MEG ohms (1 gigohm)
	OHMS READ	Activates current generator relay to apply current generator output to unknown resistance.
	Interlock	Connects probe compartment shield to front panel when door is open and to guard shield when door is closed.
	AMPL	Disconnects the output limiting diodes and meter to permit output voltage to rise to <u>+10</u> volts.
	METER	Connects output limiting diodes to limit output voltage to approximately <u>+2.8</u> volts (overload condition) and connects meter to provide metered output.
	ZERO	Electronic zero control on all resistance ranges, current ranges from 0.1 nanoamperes through 100 microamperes, and voltage ranges from 1 microvolt through 1 volt. S101 disables ZERO control on current ranges above 100 microamperes and on voltage ranges above 1 volt.

- a. Avoid touching the volt/ohms probe clips, especially the metal tips, as much as possible to prevent unnecessary heating of the clips.
- b. Short test probe clips together to discharge input filter.
- c. Connect volt/ohms probe clips into circuit under test at points having substantially the same temperature where possible.
- d. Isolate the measurement points from heat-producing or heat absorbing components and from movement of air currents by covering measurement points with a cloth. Fold cloth into several layers for additional insulation if necessary.

NOTE

Thermal and electrostatic shielding for small electronic components is conventionally obtained by placing items under test in top shelf of probe storage compartment and closing door.

- e. Remove hands, soldering irons, etc., from close proximity to measurement points.
- f. Allow test clips and circuit conductors to reach the same temperature (as indicated by minimum thermocouple voltage) to minimize thermocouple effects. When making OHMS measurements, zero out the thermocouple voltage.
- g. Read and record measurement value.

2.4.3. MINIMIZATION OF SPURIOUS SIGNALS. The following procedure will minimize the effects of stray noise pickup.

- a. Enclose circuit point being measured with an electrostatic shield.
- b. Connect electrostatic shield to microminiature "C" shield at clip with black spool on volt/ohms probe or metal shield on output probe.
- c. Ensure that probe cables are motionless. (Probe cables which are flexed during measurement generate large noise spikes.) Probe cables which are

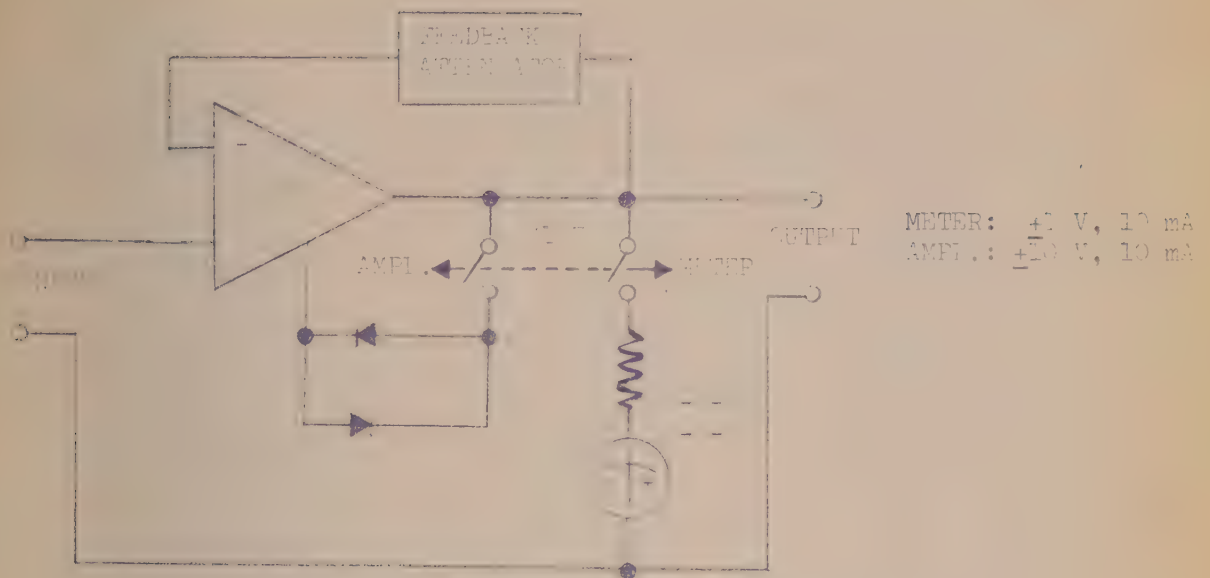


Fig. 1. Simplified AMPL.-METER Switching.

Table 2-6. Voltage Amplification.

RANGE		VOLTAGE GAIN		MAXIMUM GAIN ERROR
VOLTAGE	CURRENT	VOLTAGE FUNCTION	CURRENT FUNCTION	
1 pV	0.1 nA	1,000,000.0		10%
1 nV	1 nA	333,333.3...		10%
10 pV	1 nA	100,000.0		10%
100 pV	1 nA	33,333.3...		10%
1 mV	10 nA	10,000.0		10%
10 mV	10 nA	3,333.3...		10%
100 mV	100 nA	1,000.0		10%
1 V	100 nA	333.3...		10%
10 V	100 nA	100.0		10%
100 V	100 nA	33.3...		10%
1000 V	100 nA	10.0		10%
10000 V	100 nA	3.3...		10%
100000 V	100 nA	1.0		10%
1000000 V	100 nA	0.33...	0.33...	10%
10000000 V	100 nA	0.10	0.10	10%
100000000 V	100 nA	0.033...	0.033...	10%
1000000000 V	100 nA	0.010	0.010	10%
10000000000 V	100 nA	0.0033...	0.0033...	10%
100000000000 V	100 nA	0.0010	0.0010	10%

The low impedance amplifier output is well suited for driving strip chart recorders and digital voltmeters. The availability of the amplifier output enables simultaneous digital data logging of the 208R measurement value for a permanent record by converting the amplifier output to digital form with a digital voltmeter and recording the output with a digital printer or digital recorder. The 208R when in the amplifier-only mode, functions as a precision amplifier or signal conditioner.

and has a dynamic input range 10 times greater than the voltage range to which the 208R RANGE switch (S101) is set. (except that the input voltage is limited to 1 KV).

2-15. DC VOLT METER OPERATION.

DC voltage is measured as follows:

- a. Extend Model 208R-02 Volt/Ohms Probe cables and plug probe into J101.
Close probe storage compartment door.
- b. Set FUNCTION switch (S102) to VOLTAGE.
- c. Set POWER switch (S103) to FILTER. (If source is very quiet, *filter*,
may be set to OFF position.

See Figure 2-3.)

- d. Set RANGE switch (S101) to range *higher than* expected measurement value.
(This instrument will withstand *severe* overloads. Refer to Table 1. Maximum Input Overload.)
- e. Clip with WHITE spool is HIGH input; clip with BLACK spool is LOW input.
- f. Short probe clips together to ensure discharge of input filter.

WARNING

Re-energize equipment under test when repairing
lethal or moderately high voltages before con-

this warning can result in severe shock, injury,
or death of operator.

NOTE

Model 208R-02 Volt/Ohms Probe clip half with blue sleeve on handle is disconnected from measurement circuit when FUNCTION switch (S102) is set to VOLTAGE. Ensure that clip half with black sleeve contacts circuit being measured when clip halves are separated by an insulating medium such as one side of an etched circuit board or by the insulating nut of a 5-way binding post.

- c. Connect probe clips to circuit under test and read measurement value.

NOTE

If pointer rises to final value very slowly, input filter is being charged from a high impedance source.

- h. Short probe clips to discharge input filter before taking a new reading.

The 208R meter can accurately accomplish all measurement functions by sensing the voltage drop across its internal components. Since this is true, voltage can be measured directly even when the FUNCTION switch (S102) is set to 10 OHMS or to 1M OHMS as long as the OHMS READ switch (S105) is not pressed. The voltage range is limited to 1 volt, one scale, when the function switch is set to 1M OHMS.

208R-01 DC AMMETER OPERATION

DC current is measured as follows:

- a. Extend Model 208R-01 Current Probe cable and plug probe into J102. Close probe storage compartment door.
- b. Set FUNCTION switch (S102) to CURRENT.
- c. Set RANGE switch (S101) to range higher than expected measurement value. The meter will withstand severe overloads. Refer to Table 1, Maximum Input Overload.
- d. The meter indicates the direction of conventional current flow from RED probe clip to BLACK probe clip.

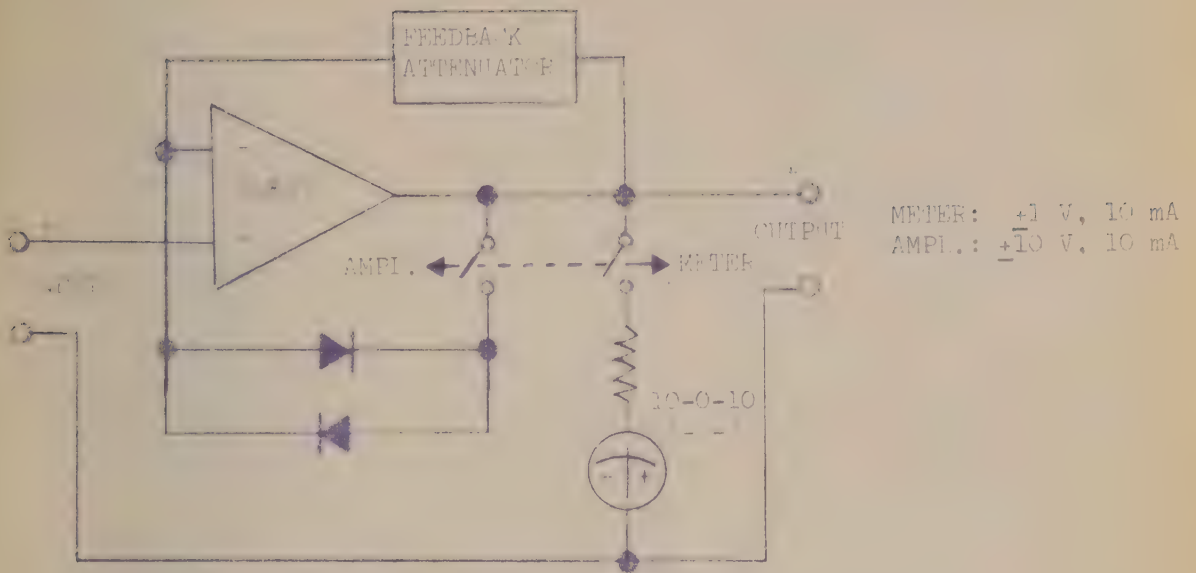


Figure 2-3. Simplified AMPL.-METER Switching.

WARNING

Do not touch shell or metal binding post of output probe connector when circuit under test is energized. The shell of the output probe is always at the same potential as the low side of the current probe (input probe) which may be as much as 1 kilovolt above ground in some circuits. Failure to heed this warning can result in severe shock, injury, or death.

c. Connect probe into circuit and read measurement value.

2-17. EXTENDED RANGE AMMETER OPERATION. The maximum end scale current range of this instrument is 100 milliamperes. However, the current range can be extended _____ by taking advantage of the ability of the micromultimeter to measure low voltage levels and low values of resistance. By measuring the resistance of any conductor in the circuit in which it is desired to know the amount of current, the voltage drop across that resistance is directly proportional to the current in that circuit. If the _____ resistance is adjusted to be some decade fraction of 1 ohm (by sliding one clip along the conductor until the correct _____ value is obtained), then the value of the current can be read directly from the meter scale by measuring the voltage drop across the ^{conduct^r} resistance. Do not move the probe clips once the correct shunt resistance is obtained until the sequence of current measurement is complete. If current and voltage measurements must be made alternately, use of an additional Model 208R-02 Volt/Ohms Probe will permit such alternate measurements without changing the shunt. Table 2-7 relates the voltage range settings to end scale current values for current shunts of 1 milliohm, 10 milliohms, 100 milliohms, and 1 ohm. It is recommended that shunt resistances less than 10 milliohms not be used where accurate measurements are required due to the difficulty of adjusting and measuring the shunt resistance accurately due to thermal effects on the more sensitive resistance ranges. Often no wire conductor is long enough to function as a shunt on printed circuit boards. In this case, any low resistance in the circuit (less than 10 ohms for current ranges greater than 100 milliamperes) can function as a shunt. Current measurement is then computed by dividing the measured voltage drop by the measured shunt resistance according to Ohm's law.

An alternate procedure is to connect one clip to a component lead in series with the current being measured and to hold the other clip against the foil conductor with the voltmeter side of the clip (check sleeve in contact with the conductor while making the measurement). This method suffers from the fact that body heat conducted through the clip will produce a false differential voltage which must be taken into account for each measurement.

any time the current is measured, the current is measured in the direction of the arrow. The current is measured in the direction of the arrow. The current is measured in the direction of the arrow.

Table 2-7. Current Measurement with Reduced Shunt Resistance, Extended Equal Current Ranges

2-18. GALVANOMETER OPERATION.

The 208R Micromultimeter functions as a calibrated current and voltage galvanometer simultaneously with its voltage and current measuring functions. It also functions as a voltage galvanometer on HI OHMS and LO OHMS as long as the OHMS READ switch is not pressed. Refer to Table 1, Specifications, for full galvanometer specifications and sensitivities. The very high input resistance of this instrument

makes it an excellent null indicating device for circuits in which sensitive components, such as standard cells, will not tolerate continuous low current draws. The instrument will not be disturbed by an external magnetic field.

2-19. OHMMETER OPERATION.

2-20. LO OHMS MEASUREMENT. The LO OHMS function is used for measuring resistances less than or equal to 300 ohms. Low resistances are measured in 12 x 1 and 30 overlapping ranges by a four-terminal method which supplies a constant current of 1 milliampere directly to the unknown resistance to produce a voltage drop which is measured by the meter. Figure 2-1 is a simplified diagram of the four-terminal method of resistance measurement.

Table 2-7. Extended Current Ranges: Current Measurement With Reduced Shunt Resistance.

Voltage Range	CONDUCTOR RESISTANCE			
	100 Ω	100 m Ω	100 $\mu\Omega$	100 n Ω
200 mV			1 mA	100 mA
200 μ V			100 μ A	10 mA
20 mV	2 mA	10 mA	100 μ A	1 A
200 μ V	2 m Ω	30 mA	500 μ A	5 A
2 mV	2 m Ω	100 mA	1 A	10 A
20 mV	2 m Ω	300 mA	3 A	30 A
200 mV	20 m Ω	1 A	10 A	
2000 μ V	200 m Ω	1 A	10 A	
2 V	1 A	1 A		
20 V	1 A	1 A		
200 V	1 A			
2000 V	1 A			

NOTE: If the exact conductor resistances (acting as the current shunt) specified above cannot be maintained conveniently, the current may be computed by measuring the resistance of any convenient conductor segment, measuring the voltage drop across that conductor segment while functioning as a shunt, and computing the current by the relationship $I = E/R$, where I is in amperes, E is in volts, and R is in ohms. For best results, do not move the probe clips after determining the resistance of the conductor until measurement is complete. When the FUNCTION selector is set to LO OHMS, the instrument reads voltage directly as long as OHMS READ is not pressed.

Figure 2-1. Simplified Diagram of Four-terminal Method of Resistance Measurement

To measure LO OHMS:

- Extend Model 208R-02 Volt/Ohms Probe cables and plug probe into J101.
Close probe storage compartment door.
- Set FUNCTION switch (S102) to LO OHMS.
- Set power switch (S103) to FILTER.
- Set RANGE switch (S101) to estimated resistance range.
- Connect probe clips to leads of resistance to be measured. Ensure that both halves of clip contacts lead wire. (See Figure 2-3.)
- Press OHMS READ switch (S105) to energize current generator and read resistance from meter.

2-21. HI OHMS MEASUREMENT. The HIGH OHMS function is used for measuring resistances greater than 300 ohms. High resistance measurements are measured in 7 decades ranges from 1 kilohm to 1 gigohm by using feedback to increase the source resistance of the current source.

To measure HI OHMS:

- Extend Model 208R-02 Volt/Ohms Probe cables and plug probe into J101.
Close probe storage compartment door.
- Set FUNCTION switch (S102) to HI OHMS.
- Set RANGE switch (S101) to voltage range indicated by HI OHMS arrow in perimeter of range indicator.
- Set HI OHMS range switch (S104) to estimated resistance range.
- Press OHMS READ switch (S105) to energize current generator and read resistance from meter.

2-22. OHMS MEASUREMENT WITH INCREASED RESOLUTION AND ACCURACY. Resistance can be measured with increased resolution and accuracy that provided by a meter measuring an unknown voltage with a constant current and full voltage. Absolute accuracy of measurement is increased and accuracy

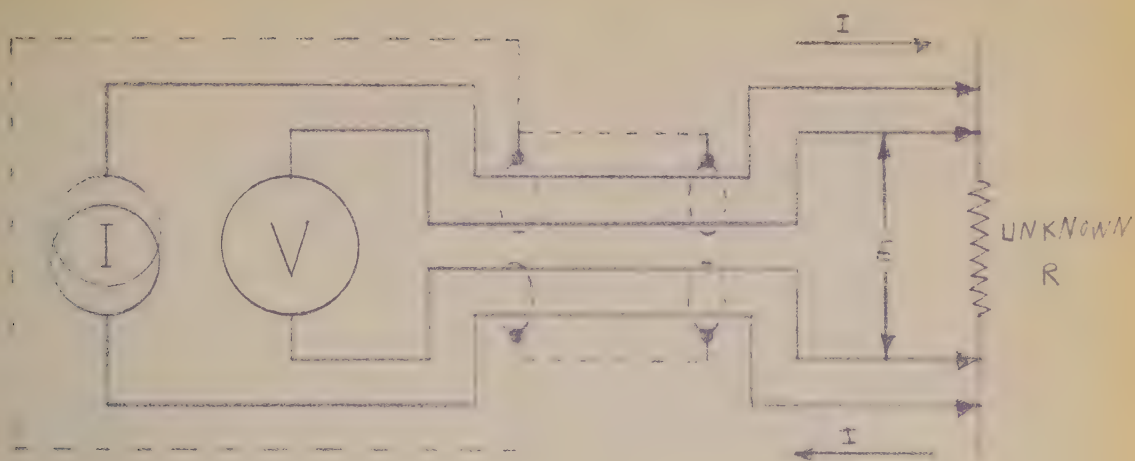


Figure 2-4. Simplified Diagram of Four-terminal Method of Resistance Measurement.

of comparative resistance measurements is extremely good. The accuracy of measurement is dependent upon the current generator's output being exactly 1 milliampere. Since the current generator output is slightly temperature sensitive, maximum precision is assured only if the current generator is calibrated immediately before making precision measurements. (Refer to Section IV for calibration procedures.)

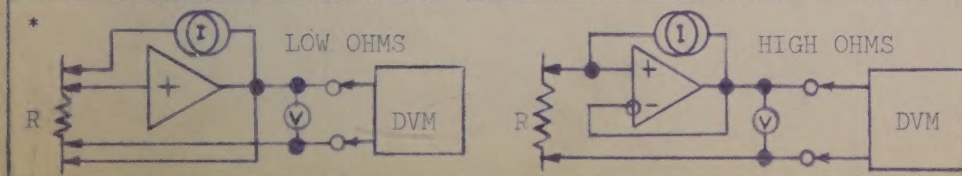
Table 2-8 tabulates the various resistance ranges and attainable accuracies of resistance measurement together with appropriate test procedures.

Table 2-8. Resistance Measurement with Increased Resolution and Accuracy

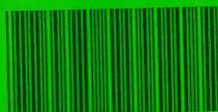
Table 2-8. Resistance Measurement With Increased Resolution and Accuracy.*

RANGE ¹	ERROR = X% OF READING		METERED ⁴ OUTPUT (1 VOLT, END SCALE) RANGE SCALE FACTOR	AMPLIFIER-ONLY OUTPUT ⁵ (10 VOLTS, END SCALE)	
	(NORMAL CALIBRATION) ²	(SPECIAL CALIBRATION) ³		RANGE SCALE FACTOR	END SCALE RESISTANCE RANGE
LO OHMS					
1 0	1.5%	0.7%	x1	x10	10 0
3 0	1.5%	0.7%	x1	x10	30 0
10 0	1.5%	0.7%	x1	x10	100 0
30 0	1.5%	0.7%	x1	x10	300 0
100 0	1.5%	0.7%	x1	--- ⁶	-----
300 0	1.5%	0.7%	x1	--- ⁶	-----
HI OHMS					
1 KO	1.5%	0.5%	x1	x10	10 KO
10 KO	1.5%	0.5%	x1	x10	100 KO
100 KO	1.5%	0.5%	x1	x10	1 MO
1 MO	1.5%	0.5%	x1	x10	10 MO
10 MO	1.5%	0.5%	x1	x10	100 MO
100 MO	1.5%	1.0%	x1	---	-----
100 MO	1.5%	3.0%	--	x10	1 GO
1 GO	3.0% ⁷	3.0% ⁷	x1	--- ⁶	-----

1. S101 setting. Noise limits the usefulness of this method on lower ranges, and shunting of the unknown resistance by the amplifier input resistance limits its usefulness on the highest ranges.
2. Standard calibration of current generator. The tabulated error does not include the reading error of the digital voltmeter.
3. The current generator is adjusted to deliver exactly 1 milliampere on the selected range at ambient temperature at the time of measurement per calibration procedure, Section IV. The tabulated error does not include the reading error of the digital voltmeter.
4. S107 set to METER.
5. S107 set to AMPL.
6. Compliance of current source prevents use of these ranges.
7. The digital voltmeter provides increased resolution but no increase in accuracy due to residual non-linearity caused by shunting of unknown resistance by amplifier input resistance. Calibration is for best straight-line fit of indicated-resistance curve ($\pm 3\%$).



MP MASTER



MA30146